

2. On the Soft Anatomy of the Musk-Ox (*Oribos moschatus*). By Dr. EINAR LÖNNBERG.¹

[Received January 25, 1900.]

When last spring (1899) it was decided that a Swedish Expedition under the direction of Professor A. G. Nathorst should start for Greenland, Professor T. Tullberg suggested the importance of obtaining examples of the viscera and other parts of the Musk-ox; and sent out the necessary outfit for this purpose. Professor Nathorst, as is well-known, made in the 'Antarctic' a successful voyage; and arriving early in East Greenland, he had ample time for geographical and other researches.

Musk-oxen were found and shot at several places. The Zoologist of the Expedition, Ivar Arwidson, accordingly had the opportunity of making a good collection. The animal was, however, found to be of greater bulk than was expected, and it was therefore with no little difficulty that its different parts were preserved, the receptacles being found rather small for the purpose. Nevertheless, the following organs were secured (skins, skeletons and skulls not being counted):—

Of an old bull killed the 9th of July on Sabine Island and measuring 228 cm. in length: alimentary canal with appendages, liver, spleen, &c.; lungs and heart; urinogenital organs (partly damaged); eyes, larynx, tongue and the lining of the mouth. Of a young cow killed the 11th of July in Queen Augusta Valley: udder and histological material from different organs. Of an old cow killed the 26th of August at Emperor Franz Joseph Fjord: udder. Of an old bull killed the 29th of August: urinogenital organs. In addition to this two brains and certain other specimens.

When the expedition returned it was, with the consent of Professor Nathorst, agreed that the present writer should be allowed to investigate the material mentioned above; and he has now the honour to lay before the Society the results of this investigation.

The muzzle of *Oribos* is covered with short hair, with the exception of a strip along the upper margin of either nostril, which is naked, and probably in the living animal moist. This naked part has a papillary surface. The naked strips above the nostrils in an adult bull are about 8 mm. broad, and extend in a median direction so as to meet on the anterior surface, where the naked region is a little broader. So far the condition of the muzzle has a certain likeness to that of a Sheep². There is, however, a great difference, because in *Oribos* there is not the slightest trace of that vertical,

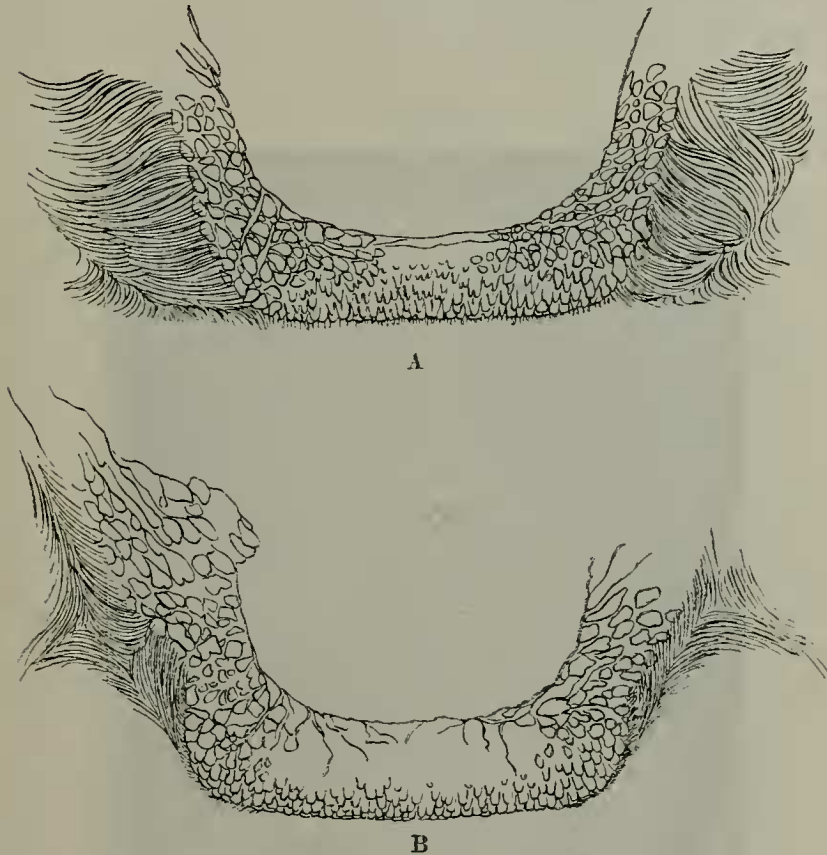
¹ Communicated by R. LYDEKKER.

² The hairiness of the muzzle can very well be explained as an adaptation to the cold climate, and there is no need to regard it as a sign of affinity between the Sheep and the Musk-ox. Compare the Reindeer! But it may also be an ancient characteristic. Compare the Antelopes!

bare fissure (*philtrum*) extending from the naked area between the nostrils over the upper lip, which is so characteristic of the Sheep and their allies. With regard to shape, the muzzle of *Ovibos* is more flat and broad, and its nostrils are wider apart than in the Sheep, although closer than in an Ox. The nostrils are not so widely open as in an Ox, and not so closed by the upper flap as in the Sheep.

Both upper and lower lips (fig. 1) are anteriorly broad and beset

Fig. 1.



Upper (A) and lower (B) lips of the Musk-ox.

with hard warts; this warty area being in an adult bull about 2 cm. broad and $7\frac{1}{2}$ cm. long. The warty areas of the lips work against each other as the jaws of a pair of pincers, and are apparently well fitted for seizing the food. The Musk-ox thus browses with its lips. The mouth is square, but must be called small, as the distance from the anterior angle to the corner of the mouth is not more than $7\frac{1}{2}$ cm., or the same as the breadth of the lips anteriorly.

The palatal ridges (*rugæ palati*), fig. 2, are 13-14 pairs in addition to the first undivided one. They are often irregular, so that in some

only the median, in others the lateral part is developed. They are in their posterior margin strongly denticulated, and resemble in this respect those of an Ox. The number of such palatal ridges is also about the same in the Ox; but in *Ovis* (11-12) and *Capra* (11) the number is smaller, and there are no denticulations, or only traces of such, in the foremost ones. In *Capreolus* I have counted 12-13 distinct palatal ridges, of which the anterior ones are striated and crenulated. In this respect *Oribos* resembles *Bos* more than the others.

The *papilla palati* of *Oribos* is more rounded than in *Bos* and *Ovis*, not anteriorly, but only posteriorly, and especially on the sides, where the ducts from Jacobson's organ open, divided by a

Fig. 2.



Palatal and buccal surface of the Musk-ox.

furrow from the adjoining parts. In this respect it resembles *Capra*; but *Capreolus* and *Rangifer* have a triangular *papilla*

palati, entirely surrounded by a furrow which also extends forward. The inner side of the lips and of the buccal tracts (fig. 2, p. 144) is provided with a large number of strongly developed conical papillæ. In a region of the upper lip in front of the upper molars these are simply conical, measuring 7-8 mm. in length. In other parts they are chiefly 2- or 3-pointed. In the middle part of the buccal tract and along the molars these papillæ sometimes measure as much as 5 mm. in breadth at their base, $6\frac{1}{2}$ -7 mm. in height, and they are provided with 7-8 acute points. Further in the papillæ are not so densely crowded, but become more scattered. The posterior ones are also comparatively more stout and bluntly conical, and in those parts single-pointed ones are also seen. *Ovibos* seems to differ in this respect from *Bos* and *Ovis*, in which, at least as a rule, these papillæ are single-pointed. In *Capra* the papillæ in question are mostly single-pointed, but in the row on the outside of the upper molars I have seen 2- and 3-pointed papillæ, and in the corresponding series of the lower jaw the usual number is 3 or more points. In *Capreolus* some few of the buccal papillæ have more than one point, and in *Rangifer* this is to a great extent the case.

On both sides along the insertion of the tongue there is a series of large conical papillæ. The most anterior of these especially have more than one point in *Ovibos*. In *Capra* and *Ovis* the corresponding papillæ are simple, so far as I have seen, but in *Capreolus* some of the anterior ones are double- or triple-pointed.

The *caruncula sublingualis* in *Ovibos* consists of a triangular flap inserted along its median side, and with the tip of the lateral point curved forward. At the base of this triangular flap lies posteriorly another digitiform, but flattened papilla, which extends forward along its lateral margin. This condition is different both from that of *Bos*, in which a broad flap is found, and that of *Ovis* and *Capra*, in which there is a large triangular flap anteriorly, behind which are two smaller ones. In *Capreolus* this caruncula is elongated and semilunar, with 6-7 marginal denticulations.

The tongue of an adult bull (fig. 3, p. 146) measures about 27 cm. in length. Its anterior and broadly rounded end is 6 cm. in breadth. In the middle it is narrower, measuring $4\frac{1}{2}$ cm., but its hind part is again nearly 6 cm. The posterior convex portion is very much thicker (about 56 mm.) than the flat anterior (about 33 mm.) part, and divided from it by a transverse groove. This groove is situated exactly in the middle of the tongue, $13\frac{1}{2}$ cm. from either end. On the anterior portion an asperity is produced by the dense covering of the horny *papillæ filiformes*, which are flattened and almost scale-like, but pointed. The same covering also extends $1-1\frac{1}{2}$ cm. over the lower side of the tongue, especially anteriorly. Towards the sides the papillæ are less flattened and more filiform. Posteriorly they increase in size, and are more pronouncedly scale-like. In the transverse groove their breadth is nearly 1 mm. *Papillæ fungiformes* are scattered all over the anterior portion of the tongue, although rather widely (8 mm.) separated in its central

part. Towards the sides they are more numerous, 4 mm. apart. At the margin they are still closer, 3 mm. or less apart, and on the lower side of the tip of the tongue they are separated by interspaces not even measuring 2 mm. Anteriorly, the diameter of the *papillæ fungiformes* is 1 mm. or not quite that, but they increase in size posteriorly, so that the diameter of those in the groove measures $1\frac{1}{2}$ mm.

Fig. 3.



Tongue of the Musk-ox.

The posterior thick portion of the tongue is covered by large, horny, scale-like papillæ. They are 2 ($2\frac{1}{2}$) mm. broad in the median region, but their size diminishes towards the sides, where they measure only about 1 mm. These are homologous with the small papillæ on the anterior portion of the tongue, but are rounded instead of pointed. The lateral surface of the posterior portion of the tongue is beset with minute and conical *papillæ filiformes*. Laterally, and on the posterior two-thirds of the central region of the hind tongue, rather large *papillæ fungiformes* are

found, but none on the anterior third of the central region. Their diameter measures from $1\frac{1}{2}$ to $2\frac{1}{2}$ mm. *Papillæ circumvallatæ* are placed in two irregular rows on either side of the tongue of *Ovibos*. Their number is about 12–15. *Ovis* and *Capra* have the *papillæ filiformes* on the anterior portion of the tongue similar to those in *Ovibos*, and this is also the case with *Capreolus*, but in *Bos* they are more narrow and pointed. In all four genera, mentioned for comparison, a median region of the anterior portion of the tongue is destitute of *papillæ fungiformes* except at the tip. But, on the other hand, *Rangifer* resembles *Ovibos* in having *papillæ fungiformes* scattered over the whole of the anterior portion of the tongue, although less densely in the central region. The same is also the case with *Cervus elaphus* and *C. dama*. *Rangifer* and *Ovibos* are also alike in having the papillous covering extending about $1\frac{1}{2}$ cm. on the lateral lower surface of the tongue. In *Ovis* and *Capra* a similar arrangement of the papillæ takes place, as it also does on the sides (but not at the tip) of the *Capreolus* tongue. In *Bos* the papillæ do not extend far laterally or to the lower side of the tongue.

The papillæ of the posterior portion of the tongue in the middle are large and flattened in *Ovis*. The corresponding papillæ of *Ovibos* are comparatively less enlarged, and look more like scales than tubercles. In *Bos* (and partly in *Capra*) these papillæ are more conical and curved, especially anteriorly. The papillæ of *Ovibos* may thus be said to be in an intermediate stage of development. The papillæ of *Capreolus* are scale-like, with roundish tips, resembling in their shape those of *Ovibos*, but those of *Rangifer* are rather more pointed, and the anterior ones even conical. In *Bos* only the hindmost ones are soft, the others all being more or less horny.

Capreolus and *Rangifer* are provided with *papillæ fungiformes* only on the sides of the posterior portion of the tongue, but in *Bos*, *Capra*, and *Ovis* there are some scattered on the middle of the central region as well, although not so many as in *Ovibos*. In *Capreolus* and *Rangifer* more than half of the lateral surfaces of the posterior portion of the tongue is covered by small *papillæ filiformes*, thereby agreeing with *Ovibos*. In *Capra* the same is the case anteriorly, but in *Ovis* at least two-thirds of these parts are smooth.

Papillæ circumvallatæ occur on each side in *Ovis* 18–24 (according to Ellenberger & Müller) in 4 rows, in *Bos* 10–17 in 2 rows, in *Capra* 16–17 (12 according to Ellenberger & Müller) in 2 rows, in *Capreolus* 8–9 in 2 irregular rows¹, and in *Rangifer* 7–11 in 2 irregular rows².

¹ In *Cervus elaphus* and *dama* the number of *pap. circumvallatæ* is variable, and they are disposed in two irregular rows.

² In Bronn's Klass. und Ordn., Leche mentions that the number of *pap. circumvallatæ* is "bei *Camelidæ* sechs." The primary three on each side I have found in *Camelus bactrianus* to be the largest and best developed, but accessory ones are also found, as in one instance two on each side close to the primary, and two more on each side with a more posterior and median position.

I have described the shape and arrangement of these papillæ rather fully in order to show that these conditions hardly offer any characteristics of systematic value, as they are subject to much variation even individually, and distant forms are sometimes more alike than nearly related ones. The likeness between *Ovibos* and *Rangifer* may depend on a similar way of feeding. In both the strongly developed lips are certainly of use when they nip off lichens from rocks and stones. If they had only thin lips, they might scratch and hurt their teeth when feeding on that material. The warty laminæ on the lips are also useful when seizing other food such as the twigs of the arctic willow, and against these hard twigs the strong development of the papillæ of the mouth is of protective value. There seem to be several ways of seizing the food among the Pecora. *Bos* uses the tongue; *Ovis* and *Capra* bite at once, and their lips are chiefly taste-organs; *Rangifer* and *Ovibos* use the lips as pincers; and *Alces* uses its great movable muzzle as a kind of trunk, but the lips of the latter are smooth, not provided with horny warts as in the Reindeer and Musk-ox; the function is thus different.

The tonsils in *Ovibos* have four or five openings.

The *œsophagus* is provided with a strong outer layer of muscle ($3\frac{1}{2}$ mm.), and interiorly has longitudinal folds. These are of two kinds, namely 7-8 large ones from 2 to 4 mm. in height, and small ones measuring 1 mm. or less. The former disappear by stretching and are produced by folding of the whole mucous membrane, but the latter seem to be merely epithelial ridges¹.

The paunch is of course large. The zoologist of the expedition emptied 22 litres of fodder out of that of an old Musk-ox² from Sabine Island; but there is no proof that it was fully distended, and a quantity was left in the preserved ventricle. The right and left sacs of the paunch do not extend equally in aboral directions as in *Bos*, the right being a little the longer, as in *Ovis*. Both

Fig. 4.



Papillæ of the paunch of Musk-ox.

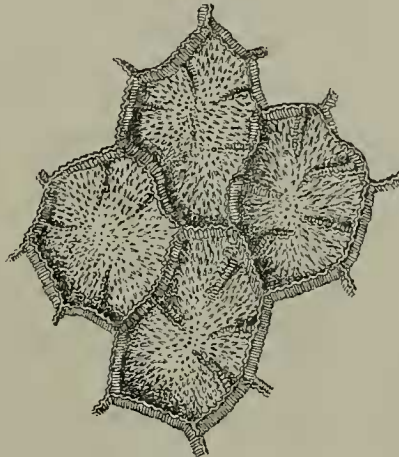
sacs are, however, more broadly rounded, and the constriction between them is, as it seems, not so strong as, for instance, in *Capra*. The distance from the cardia to the end of the left sac is 41, and to the end of the right sac 44 cm.; both measurements being taken when the stomach lies flat and empty. Transversely

¹ This agrees with the corresponding features in *Bos taurus* as described by Oppel (Lehrb. d. vergl. Anat. d. Wirbeltiere) after Schütz.

² Total length 228 cm.

measured, the diameter of the left sac is 21, and that of the right 27 cm. These measurements have of course only value for a comparison of the size of both sacs. The distribution of the exterior furrows and interior muscular ridges of the paunch seems, on the whole, to agree with the same in *Ovis*. Thus the paunch of *Ovibos* and *Ovis*, and especially its left sac, is less specialized than in *Bos*, but more so than in *Capreolus*. The papillæ in the paunch of *Ovibos* (fig. 4, p. 148) are flattened, more or less broadly tongue-shaped, and cover the whole interior surface except the muscular ridges. Their size varies from 5–15 mm. in length, and from 2 to 4 (in average $2\frac{1}{2}$ –3) in breadth. Three cm. from the cardia these papillæ measure about 8 mm. in length by 2 in breadth; at the posterior end of the left sac near the “hintere Hauptpfeiler” their length rises to 11 mm., and on the area between the spleen and the reticulum, as well as in the adjacent part of the reticulum, they are still longer, 12–15 mm. The shape of the papillæ is not different from those of *Capreolus*, *Ovis*, *Capra*, &c. It has already been hinted that a portion of the reticulum is provided with tongue-like papillæ. This area passes gradually into the normally reticulated portion. The papillæ become partly confluent and form more or less lobated walls disposed like the ridges of the typical reticulum; and at the same time the papillæ in the interspaces between these walls are greatly reduced in size. The origin of the ridges of reticulum, as well as that of the small papillæ in the meshes, can thus be plainly seen. The cells of the reticulum of *Ovibos* (fig. 5) are in the fundus about 2 cm., or a little

Fig. 5.



Cells of the reticulum of the Musk-ox.

more, in diameter, but towards the sides they are smaller, $1\frac{1}{2}$ –1 cm. in diameter. At the “Schlundrinne” the cells on one side are very small, only $\frac{1}{2}$ cm. in diameter; on the other there are no cells, only longitudinal folds. The surrounding ridges of the typical cells

are not nearly so high as in *Bos*¹, and hardly so high as in *Ovis* and *Capra*. They measure 2-3 mm. in height, but this may partly be due to contraction. The free margins of these walls in the fundus are finely denticulated, but all of them are provided with vertical ridges on their lateral surfaces. The cells are again partly divided by smaller walls into secondary cells, but this is quite irregular. The cellular interspaces are also finely reticulated by small tertiary ridges which carry small conical papillæ, and such are also found within the tertiary reticulations. This is conspicuous on places where the epithelial covering has fallen off. The reticulum of *Ovibos* is thus much more differentiated than that of *Rangifer* and *Capreolus*, in which the cells are very shallow. The difference between *Ovibos* and *Rangifer*, which both lead a similar life, indicates that no parallelism in development has taken place with regard to this organ. This, on the other hand, seems to prove that the suggestion made by Owen², that the shallowness of the cells of the Reindeer's reticulum is due to the fact that the animal obtains so much water by its swallowing snow that any reservoir for water is unnecessary, is incorrect. *Ovibos* is a representative of a more specialized ruminant type.

The diameters of the reticulum of *Ovibos* are 160×210 mm., and those of the psalterium 180×230 . The latter is thus larger; and therein *Ovibos* agrees with *Bos*, and differs from *Ovis*, *Capra*, and the *Cervidæ*³.

The number of folds in the psalterium is 61, and their arrangement is plainly quadruplicate, with folds, or septa, of first, second, third, and fourth order. Eight folds of the first order are conspicuous, embracing 7 pockets of the first order. There ought, then, to be 57 folds, if it were quite regular, but some few of the fourth order are not developed; on the other hand, there are some outside the seven pockets belonging to incomplete pockets. The quadruplicate arrangement agrees with that in *Ovis*, the same in *Bos* being quinquiplicate. I do not think, however, that much stress can be laid upon this character; this opinion being confirmed by the fact that Garrod has found in the genus *Cervus* forms with quinqu-, quadri-, and triplicate arrangement of these septa⁴. *Capreolus* is said to have a quadriuplicate arrangement of septa in the psalterium; but before me lies a specimen which has only a triplicate arrangement, without the slightest trace of the fourth system of folds. Likewise I have a psalterium of *Capra* with only a few indications of the folds of the fourth system⁵.

The psalterium-folds are beset with conical papillæ, usually almost as broad as high (about $1\frac{1}{2}$ mm.), but more acute towards the free margin of the folds than at their bases. At the opening

¹ Vergl. Anat. d. Hausthiere, achte Auflage, 1896.

² Anat. of Vertebrates, vol. iii. p. 472.

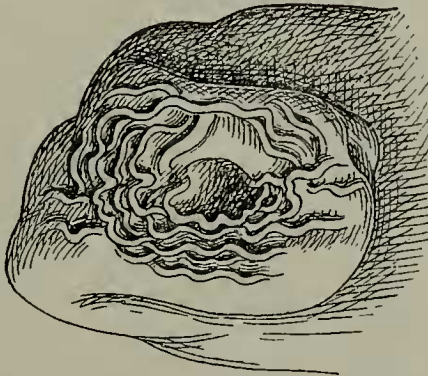
³ At least *Capreolus*, *Cervus dama*, and *C. elaphus*.

⁴ Proc. Zool. Soc. 1877, pp. 2 et seqq.

⁵ Boas has also pointed out the variability of this organ (Morph. Jahrb. 1890).

between the reticulum and psalterium are some conical papillæ, but not enlarged or curved as is usually the case in *Bos*. The psalterium-groove is also bordered by rows of conical papillæ like those of the psalterium-folds. The opening to the abomasus is surrounded by two semilunar plicæ, which are continued in the longitudinal folds of this organ. The number of the abomasus-folds of *Ovibos* is 24, many more than in *Bos* (14-16), *Ovis* (13-15), *Capra* (13), or *Capreolus* (11-12). But the folds are not very broad, at most about 3 cm. The length of the abomasus measured along the curvature is 48 cm., and its greatest breadth when lying flat and empty about 15 cm. The folds disappear 24 cm. from the pylorus. In *Ovis*, *Capra*, *Capreolus*, &c. the plicated part of the abomasus is much longer than the nonplicated. *Ovibos* has been able to shorten the plicated tract by augmenting the number of laminar folds. Towards the pylorus the musculature is strengthened, and forms a strong sphincter with a round button on the anterior side.

Fig. 6.



Irregular folds in the cæcum of the Musk-ox.

The first part of the *duodenum*, which is suspended in the *omentum majus*, is rather dilated, and measures 4 cm. in width, when it lies empty, but when it approaches the liver, 20 cm. from the *pylorus* in the *omentum minus*, it is narrowed to 3 cm. Free from this it makes a short loop about 10 cm. in length, after which it bends backward and forms another loop 33 cm. in length along the rectum, to which the ascending part is attached by a mesentery 4-5 cm. in breadth. Having returned forward, it becomes the *jejunum*, with its numerous short convolutions in the periphery of the mesentery. The last part of the small intestine is again straight, and attached to the cæcum by a narrow mesentery.

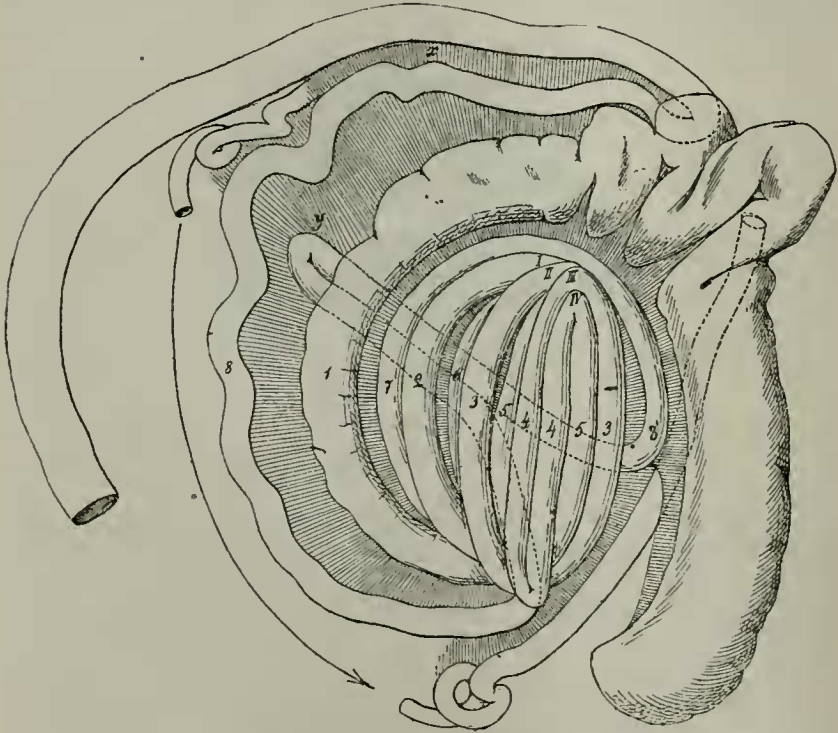
The ileum terminates by a 10-13 mm. broad circular *valvula ileo-cæcalis*.

In the fundus end of the cæcum of *Ovibos* several irregular folds are found. These are especially numerous on a spot a little more than 3 cm. in diameter, where some of the folds are 5 mm. broad. They appear to be irregularly arranged (see fig. 6). Here, too, the

wall of the cæcum is thicker. The surrounding tract shows some scattered longitudinal folds. Otherwise the internal surface is quite smooth. In the specimens of other species studied for comparison I have not seen such folds in the fundus of the cæcum.

The cæcum is dilated towards the fundus end, so that its width there is 18 cm. when it lies empty and flat, but at the opening of the ileum it is only 10 cm. The large intestine soon tapers when it enters the spiral from 10 cm., which is its width in the beginning next to the cæcum, to a diameter of 4–5 cm. in the spiral coils. It retains that width so long as it is included in the mesentery, but when it leaves this it widens to 8–9 cm. in diameter, and the rectum is still wider, 9–10 cm. When the colon leaves the spiral in the mesentery it becomes covered with fat, distributed in large oval and oblong lumps, which become still more numerous on the rectum.

Fig. 7.



Great and small intestines of the Musk-ox.

If we assume that the first spiral coil (fig. 7) begins at the point where the colon crosses the median line since it has left the cæcal tract and is bending over to the left side, then the first coil is complete at the number I in the figure, the second at II, the third at III, and the fourth at IV, but at that point the spiral turns and the colon bends back upon itself. The fifth, sixth, and seventh coils (5, 6, and 7 in the figure) are retrograde coils, and the fifth and

sixth are situated more centrally and covered by the other coils. The seventh lies between the second and first coil, but the eighth is still more peripheric. At 8 in the figure it is shown to make a long loop (*y*), and then having returned upon itself it passes out in the periphery of the mesentery near the short convolutions of the small intestine, to which it is fixed with a narrow (about 3 cm.) mesentery. Owing to this narrowness of the mesentery, the large intestine is forced to make some undulations, although not so many or so deep as the small intestine. When the large intestine has come to the pancreas region it leaves the mesentery of the jejunum, and becomes connected with the first part of the colon (the first coil) in a direction opposite to that of the latter towards the right side, and, returning upon itself, makes a loop, both ends of which are closely connected at *x* in the figure. Then it passes backward into the rectum.

With regard to the figure, it is to be observed that the intestine is laid out and the coils of the spiral are pulled apart a little; the upper parts of the spiral being to the right and the lower parts to the left, so as to make all the coils at least partly visible.

When comparing the large intestine of *Ovibos* with that of other Ruminants, it becomes evident that the former is more developed and thrown into more coils (4 centripetal and 4 centrifugal). If the spiral coils are counted in the same manner as above, we find that the colon of *Capreolus* makes $2\frac{1}{2}$ centripetal spiral coils and $2\frac{1}{2}$ retrograde or centrifugal ones. The same organ in *Capra* and *Ovis* makes 3 centripetal and 3 retrograde spiral coils. In *Bos*, as a rule, only 2 centripetal and 2 centrifugal coils (sometimes only $1\frac{1}{2}$ of each) can be discerned.

The situation of the last centrifugal coil is different in *Ovis* and *Capra* on the one side, and *Bos* on the other, since in the two former it lies peripherally quite close to the coils of the small intestine. The same is also the case in *Ovibos*, as already stated; but although this characteristic separates *Ovibos* from *Bos*, it has no value for uniting *Ovibos* with the Ovine group, because the same condition is also found in other Ruminants, as, for instance, *Capreolus*, in which the mesentery between the small and the large intestine is $1\frac{1}{2}$ – $2\frac{1}{2}$ cm. It is therefore probable that this is an ancient character retained by most Ruminants except the Bovine group. The situation of the colon gives therefore no reason for uniting *Ovibos* with *Ovis* and *Capra* in a subfamily of *Cavicornia*. On the contrary, the greater development of the spiral coils indicates that the Musk-ox is differentiated with regard to this organ from the others. The same result may be obtained by comparing the measurements of the different parts of the intestine with each other, and comparing this relation with the corresponding one in other species. The length of the different parts of the intestine of the Musk-ox measured in a preserved state, but still adherent to the mesentery, is as follows:—

Small intestine from pylorus to cæcum 26 m. 70 cm.

Cæcum 70 cm. Large intestine 12 m. 40 cm.

The terminal portion of the rectum, perhaps 25 cm., is missing.

For comparison it may be mentioned that Mr. J. Arwidson made the following measurements of the intestine of another specimen. He loosened the intestine from the mesentery and stretched it out on the deck of the steamer, which of course resulted in larger figures. Small intestine 31 m. 2 cm. Cæcum 75 cm. Large intestine 11 m. 99 cm.

But in this case, also, the last part of the rectum from the anterior end of the urinary bladder was missing. Since the intestine was stretched in this case, it may be more reliable to use my own figures. We find, then, that the small intestine is not much more than twice as long (more exactly 2.1, and according to Arwidson's measurements 2.5) as the large intestine. For comparison I have in the same way measured the intestines of a sheep and a goat preserved in formalin and still adherent to the mesentery, viz.:—

	<i>Ovis.</i>	<i>Capra.</i>
Small intestine	15 m. 15 cm.	14 m. 77 cm.
Cæcum	36 cm.	22 cm.
Large intestine	4 m. 90 cm.	4 m. 90 cm.

In both these cases we find that the small intestine is fully three times as long as the large. Similar figures occur in literature concerning other species of *Ovis* and *Capra*, and in *Bos* the small intestine is 3 to 4 times as long as the large one.

The great length of the large intestine in the Musk-ox is an adaptation suitable for the digestion of some special kind of food. It is thus probable that feeding on the twigs of the arctic willow and similar indigestible material, which, when the short arctic summer has passed, must be the only food of this hardy animal, has produced this great development of the large intestine.

The liver of the Musk-ox (fig. 8, p. 155) is divided into a right and a left lobe. The diameters of the left lobe are 16 cm. \times 21 cm., and its thickness is between 4 and 5 cm. The corresponding measurements of the right lobe are 18, 22, and 8 cm. The spigelian lobe is small and triangular ($4\frac{1}{2}$ cm. base, $2\frac{1}{2}$ height) with a broad base, thus exhibiting that shape which has been called by Garrod¹ oviform. The *lobus caudatus* (*l.c.*) is flattened, $12\frac{1}{2}$ cm. long by $8\frac{1}{2}$ broad, and carries at the end a small lobule 3.3 cm. broad and 1.8 long. The gall-bladder (*gb*) is, as usual, situated on the posterior surface of the right lobe, 9 cm. from the umbilical fissure, the depth of which is about 6 cm. It has thus a rather central position in the right lobe. When empty and contracted it is 11 cm. in length.

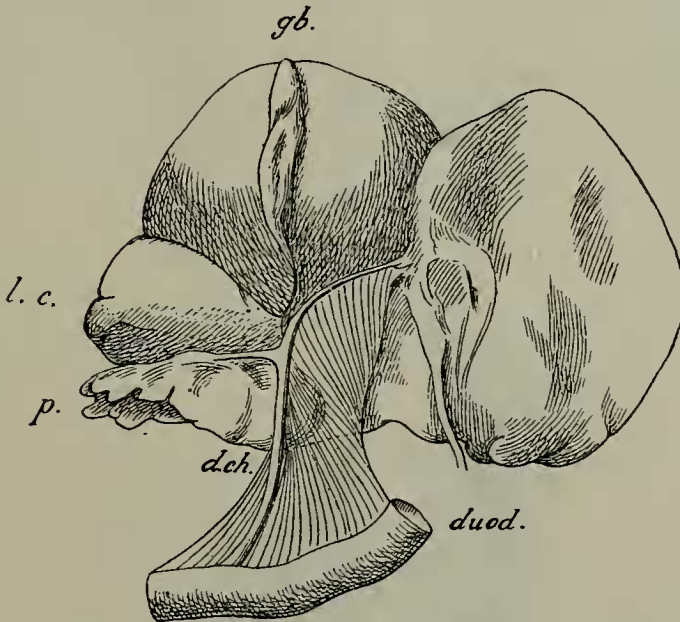
The *ductus choledochus*, which has a considerable width, opens into the duodenum 63 cm. from the pylorus. About 10 cm. before it pierces the wall of the intestine it receives the *ductus pancreaticus* (*cf.* the figure). This description being taken from the organ of a full-grown bull.

A comparison of the liver of *Ovibos* with that of other Pecora

¹ Proc. Zool. Soc. 1877, pp. 2 *et seq.*

gives the following results. With regard to its pronounced division into a right and left lobe, it resembles more the ovine than the bovine liver. But since the same division is just as much pronounced in many other forms, this characteristic has hardly any classificatory value. The *lobus spigelii* has the same form in *Ovis*, *Bos*, and *Ovibos*; but it is doubtful whether the shape of this lobe offers any valuable characteristics, since it may be absent or present in the same genus or even species, while its form in the same species may be either "rusiform" or "oviform" (cf. Garrod, *l. c.* p. 4). The shape of the *lobus caudatus* in the Musk-ox is more flattened and less trihedral than in any liver of *Cavicornia* or *Cervicornia* I have seen.

Fig. 8.



Liver, gall-bladder, and part of the duodenum of the Musk-ox.

This probably depends on the circumstance that the right kidney is not so closely impressed and capped by this part of the liver. The union of the *ductus pancreaticus* with the *ductus choledochus* before entering the intestine seems at first sight to be a character of more importance, because this presents a resemblance to Sheep and a difference from Cattle. It must be observed, however, that, according to Franck¹, *Bos* not seldom has two *ducti pancreatici*, one opening directly in the intestine, and the other uniting with the *ductus choledochus*. This considerably lessens the difference of arrangement, the more so as my preparation of *Ovibos* was a little damaged in these parts, so that I am not able to deny the possible

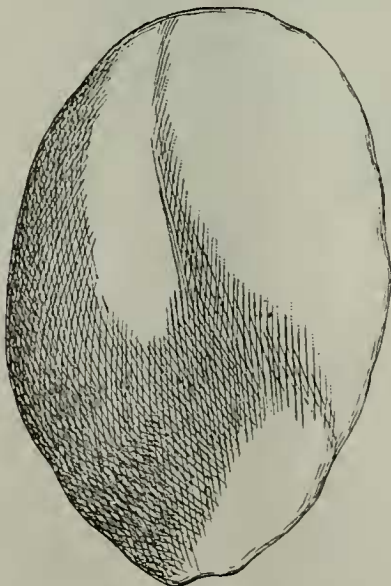
¹ Cf. Ellenberger and Müller, *l. c.* p. 433.

existence of a second pancreatic duct. By embryological investigations it has been proved that the presence of two pancreatic ducts is the primary condition, which thus is retained now and then in *Bos*; and two such ducts always exist in many Ungulata, as, for instance, *Equus*, *Tapirus*, and *Rhinoceros*. The condition in the Ruminantia does not seem to be well known (except in domesticated animals); it can, however, be concluded *per analogiam* that they originally had two pancreatic ducts. In such a case it is evident that two forms like *Ovis* and *Ovibos* have been able to reduce one and retain the other, so that this resemblance is no distinct proof of close relationship, although it may indicate such a feature.

The main mass of the *pancreas* (fig. 8, p. 155) of the Musk-ox is situated round the blood-vessels of the liver, but it extends along the paunch towards the spleen, although it does not seem to quite reach that organ. The pancreatic duct has already been spoken of.

The *spleen* of the Musk-ox is not elongate as in *Ovis* and *Capra*, but its contour is elliptic, equally rounded at both ends (fig. 9). Its length is (in an adult bull) 21 cm. and its breadth 14 cm

Fig. 9.



Spleen of the Musk-ox.

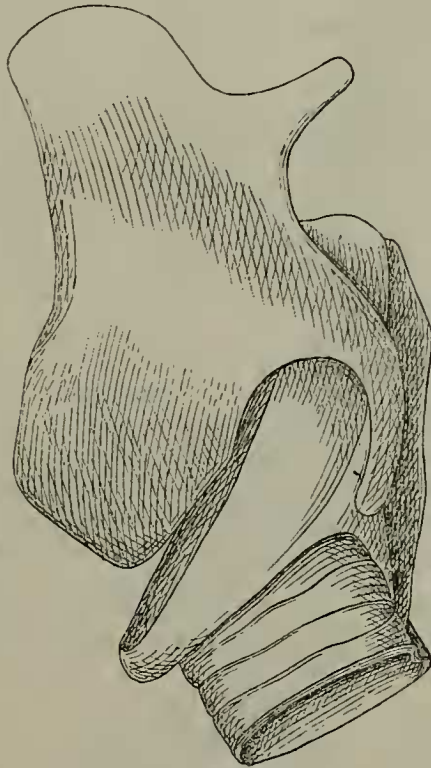
It is, however, much thicker (4 cm. in preserved state) at the side nearest to the œsophagus, and is flattened towards the other sides. Its shape thus agrees very well with that of the spleen of the *Cervicornia* (*Cervus claphus*, *Capreolus*) and *Giraffa*, and may be an ancient character.

The nostrils have already been spoken of in connection with the muzzle. The *septum membranaceum* of the posterior nasal cavity

is in the Sheep complete, and extends posteriorly into the "Nasensachen," but in the Calf it is only a ridge. In *Capra* this septum is well developed, although not quite so strongly as in the Sheep. The same structure as in *Bos* occurs in *Ovibos*, as I have seen in the salted head of a Musk-cow, in which this ridge is only 2 mm. broad and 3-4 mm. high. Even with allowance for contraction in the brine, it is evident that the posterior nasal cavity is much less narrowed by the *septum membranaceum* in the Musk-ox than in the Ovine group. This may be gathered from the fact that at the posterior end of the *palatum durum* the distance between the septum and the lateral wall is nearly $1\frac{1}{2}$ cm., while the height of the cavity measures more than 4 cm.

The *larynx* of the Musk-ox (fig. 10) is of a very elongate shape. Its greatest length (in a bull), taken as a whole, is 14 cm., but its

Fig. 10.



Larynx of the Musk-ox.

transverse (vertical) diameter is only 9 cm. This great length is mostly due to the great extension of the *cartilago thyroidea* (more than 11 cm.). It is especially the anterior part which is large, as may be demonstrated from the fact that the distance from the hind margin to the point of the *pomum adami* is contained fully three times in the distance from the latter point to the margin of

the *incisura thyroidea superior*. In *Capra* the corresponding relation is only 1 to $1\frac{1}{2}$, and in *Capreolus* I have found a similar condition. *Cornua superiora* in the Musk-ox are not so much elongated as, for instance, in *Cervus elaphus* and *Capreolus*, in which they are larger than the *cornua posteriora*, but of comparatively the same size as in *Bos* and *Capra*. They are directed dorsally, so that their direction forms a nearly right angle against the longitudinal diameter of the larynx, and is not parallel to the same as in *Capra* and *Bos*. The *cornua inferiora* are very long and arcuate. As a result of the great development of the *cartilago thyroidea* in *Ovibos*, the longitudinal diameter of the dorsal part of the *cartilago cricoidea*, which in *Capra*, *Cervus*, and *Capreolus* exceeds the length of the *cartilago thyroidea*, only equals 72% of the length of the first mentioned cartilage. In *Bos* the anterior portion of the *cartilago thyroidea* is enlarged as in the Musk-ox, so that the length of the larynx exceeds the dorsiventral diameter, but the length of the *cricoidea* equals or nearly equals the length of the *thyroidea* along the anterior keel. The *pomum adami* is less developed in *Bos* than in *Ovibos*, and the distance from the same to the insertion of the *cornua posteriora* exceeds the length of the *thyroidea* in *Bos* and still more so in *Capra*; but in *Ovibos* this distance is not much more than $\frac{3}{4}$ of the length of the *thyroidea*, although the *pomum adami* is so much protruding. This indicates that the lateral extension compared with the length of the *thyroidea* is much less in *Ovibos* than in *Bos*. This can be seen in the figure. On the whole there is, however, more resemblance with regard to this organ between *Ovibos* and *Bos* than with the others.

The *epiglottis* of the Musk-ox is strongly recurved at the apex, but blunt (nearly rounded). It thus makes a less triangular impression than that of *Capra*, *Bos*, &c. The *plica ary-epiglottica* is well developed, although not so much, it seems, as in *Ovis* and *Capra*. The basal part of the epiglottis is strongly developed and reaches the same length as the free portion. On the sides it is well curved so as to embrace the arytenoid cartilages.

The *trachea* is very wide and has a peculiar shape. It is flattened dorso-ventrally, so that the transverse diameter of its

Fig. 11.



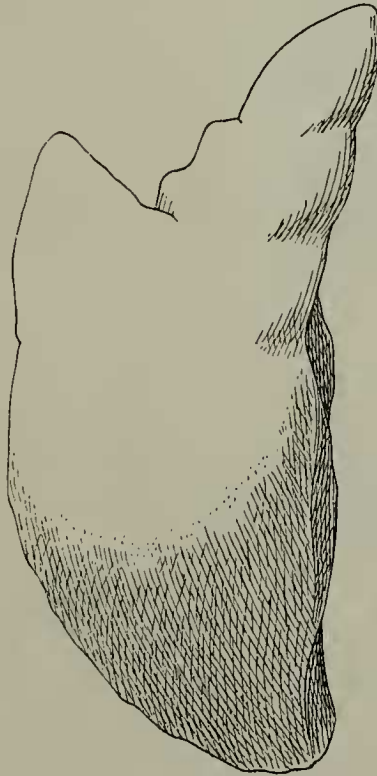
Tracheal ring of the Musk-ox.

lumen is 5 cm., but the dorso-ventral only 3 cm. This is effected by the tracheal rings (fig. 11) not meeting dorsally, but leaving a

3 cm. broad interspace between their dorsal ends¹. This interspace is occupied only by soft tissues. The dorsal surface is thus, instead of showing a median edge as in other *Cavicornia*, flat or even a little concave. The cartilages are ventrally thicker, but end dorsally in thin edges. The ventral portion of the rings is usually 7-8 mm. broad, but towards the sides, where they partly overlap each other in the antero-posterior direction, they become broader (15-20 mm.).

The *lungs* of the Musk-ox show on the right side the same division into lobes as in other *Cavicornia* (*Bos*, *Ovis*, *Capra*) and in *Cervicornia* (*Cervus elaphus*, *Dama*, *Capreolus*, and *Rangifer*), but the left lung differs (fig. 12) from all the material (of Ruminants)

Fig. 12.



Lung of the Musk-ox.

on hand except *Lama glama*. The left lung is quite simple, the upper lobe sitting with a broad base on the lower, and there being no trace of a middle lobe (see fig. 12), which latter in the Ruminants (except *Lama*) enumerated above is very deeply cleft from the lower lobe. *Ovibos* has thus in this, respect, a very isolated position. The lungs are distinctly lobulated as in *Bos*.

¹ A similar condition is said to take place in the Yak (*Bos grunniens* Linn.) according to Pagenstecher (*Allgem. Zoologie*, vol. iii. p. 384).

The circulatory system cannot be studied from the material on hand, I therefore only state the dimensions of the preserved heart of a Musk-ox bull, $18 \times 13\frac{1}{2} \times 9\frac{1}{2}$ (right) or $10\frac{1}{2}$ (left) cm. Its periphery is 39 cm. The dimensions seem to equal those of common cattle.

The scrotal sac of the Musk-ox is pendent, with vertical testicles, as Mr. J. Arwidson informs me. The length of a testicle with the epididymis of a bull (killed at Emperor Franz Joseph Fjord, Aug. 26) measured $12\frac{1}{2}$ cm., the transverse diameter of the same is about 6 cm. This is about the same size as in cattle, and relatively smaller than in *Ovis* and *Capra* (for instance the testicles of a young goat are fully 10 cm. in length). The *musculus cremaster* is well developed, $3\frac{1}{2}$ cm. broad. The *vasa deferentia* are arranged as usual. The thickened terminal portions are 6–7 mm. in length and about 7 mm. thick. They have an exterior muscular coat and a spongy-looking interior surface. The interspaces between these organs are filled with fat. The *ductus ejaculatorius* opens on a *colliculus seminulis* which has the shape of a ridge, but distally this ridge is cleft in two parts, which border a furrow.

The *vesiculæ seminales* are flattened, $5\frac{1}{2}$ cm. long and $2\frac{1}{2}$ cm. broad, organs with a distinctly lobed appearance. They are nearly solid and have a glandular structure. Each opens with a duct into the corresponding *ductus ejaculatorius*.

The *prostata* is only slightly developed, and covered by the thick *musculus urethralis*. Next to the bladder only small scattered lobules are seen, but distally, $4\frac{1}{2}$ cm. from the proximal border of this muscle, the gland is thickened to a layer 5–6 mm. in thickness and about $1\frac{1}{2}$ cm. in length.

The *glandulæ cowperi* are well developed, rather triangular in shape, about 3 cm. deep, and nearly $3\frac{1}{2}$ cm. long, but flattened on the median side so that the thickness does not amount to more than $1\frac{1}{2}$ cm. in the transverse diameter.

So far as the muscles are left on the preparation, the following can be discovered:—a pair of broad *ischio-urethrales*, a pair of large *bulbo-cavernosi* and the “*Afterruthenmuskeln*,” which run alongside each other to the S-shaped curve of the penis. There they separate, and continue laterally of the penis to a point about 6 cm. from the *præputium*, where they insert by means of a sinew.

The *penis* opens into a *præputium*, which protrudes $6\frac{1}{2}$ cm. outside the integument of the belly. The distal third of this sac-like prominence is exteriorly naked in a bull killed August 29th. The base is covered by dark brown, nearly black hairs partly reaching a length of 18 cm. Distally the hairs get shorter, less numerous, and partly greyish white. The *præputial* cavity is distinctly differentiated into three regions with different structure. The most distal of these, which corresponds with the protruding part, is richly provided with longitudinal folds. Its integument has the same structure as the exterior surface of the tip of the *præputial* prominence. In a bull killed in July this portion is densely covered by fine hairs reaching a length of 6 cm. This is probably

a part of the winter coat, which extends even on to the interior surface of the præputium, for in the bull killed 29th August it is absent and the corresponding surface naked. The next præputial region, about 7 cm. in length, is also thrown into strong longitudinal folds. In the bull killed in July it is beset with fine woolly-looking hairs about $1\frac{1}{2}$ or 2 cm. in length. This portion is evidently richly provided with glands, for in the specimen killed at the end of August, at a time when the rutting-season is approaching, this region is quite covered by a hardened secretion. This is a yellowish-looking mass consisting partly of small roundish nodules like hardened drops and emitting a strong odour of musk. The third and most interior portion, which includes the distal end of the penis, is about 6 cm. in length. Its surface is thrown into a still greater number (16-18) of undulating folds. But the surface is smooth, and there is no secretion conspicuous in this part. There seems to be a rather powerful sphincter at the centre of the middle præputial portion, although it is damaged on the preparations.

The length of the two penes preserved in the retracted state is, measured along the curves, respectively 55 and 62 cm.

The end of the penis (fig. 13) is blunt, and the urethra ends as a truncate tube (*u*), which on the left side is curved upward close to the tip of the penis. The urethral tube accordingly does not

Fig. 13.



Penis of the Musk-ox.

extend beyond the penis, and the portion which is not fused together with the end of the latter is very short. On my specimens the free margin on the left lateral side is about 9 mm. and on the median side hardly 4 mm. This condition differs widely from that in the Ovine group. But there is still another difference: the apex of the penis of the Sheep is provided with an expansion like a cushion, forming a kind of glans, but in the Musk-ox nothing of that sort can be seen. The shape of the penis of *Ovibos* is most similar to that of *Damaliscus pygargus* as figured by Garrod (*l. c.* p. 11). From the fact that forms so widely different as *Giraffa*, *Moschus*, *Elaphodus*, *Addax*, *Gazella*, *Capra*, and *Ovis* have the urethra prolonged to a more or less setiform appendix beyond the tip of the penis, it may be concluded that this is an ancient characteristic¹ of the Ruminants, and the ancestors

¹ It is very difficult to understand such a feature as a parallelism, and *tertium non datur*.

of *Ovibos* probably had a similar organ. It is, however, reduced in the Musk-ox as well as in the Common Ox and many other forms. Such a thin filiform termination of the urethra must easily be damaged by frost, and it could hardly be useful to an animal living in such a cold climate that it needed even the interior of the præputial sac clothed with hairs or wool. This might therefore be the reason for its reduction in *Ovibos*, whatever it may have been in others.

The absence of this filiform prolongation (the cause may be one or the other) is, however, a resemblance to the condition in *Bos*, and the value of this characteristic seems to gain more importance as it is shared also by some Antelopes (*Bubaline* section). But it must be admitted that the reduction of such an appendix as this might have taken place in different forms independently.

The genital organs of a young virgin cow killed in the Queen Augusta Valley in July were preserved. The ovaries are irregularly bean-shaped, 22 mm. long, 17 mm. broad, and 12 mm. thick.

The *tubæ fallopæ* pursue their slightly winding course in about 10 cm. from the pavilion to the *cornua uteri*. In each cornu there are a great number of cotyledonal processes. These are neither regularly arranged nor of the same size, but in the wider part they seem to be disposed in four rows. Those of the two median rows are much the larger. The number may be estimated between 90 and 100 in each cornu. The cotyledons are thus much more numerous than in other forms, nearly twice as many as in the cow and sheep (according to Franck¹). According to Garrod's list the Giraffe is the only ruminant which has a similarly great number, namely "180 large and small" (*l. c.* p. 12). *Ovibos* has accordingly a rather isolated position in this respect.

The *corpus uteri* is very short (about 12 mm.), because the cornua nearly reach down to the *cervix*. The vaginal portion forms the largest part of the genitalia in such a young cow. It is about 19 cm. from the lower end of the *canalis cervicis* to the edges of the *labia pudendi*. About a third of this length is taken up by the *sinus urogenitalis*. The *hymen* is well developed, and at its free margin is a conical papilla. Under the *hymen* is a diverticulum in which the urethra opens.

The *vagina* from the *hymen* to the *cervix uteri* is wide and about 13 cm. in length. Not far from the end of the same, two large plicæ or valves are found, which are arranged so that each forms a pocket with the wall. The interior of these is situated on the left side about 2 cm. from the mouth of the *canalis cervicalis*, and its pocket is open downward. The exterior valve forms a still more pronounced pocket opening inward a little more than 2 cm. from the other. The function of these valves may be to retain the sperm in the vagina after copulation. Otherwise the interior surface of the vagina is smooth, but with longitudinal folds. In the Ruminants that I have used for comparison, I have not seen any

¹ Cf. Ellenberger and Müller, *l. c.* p. 556.

transverse plicæ or valves like those in *Ovibos*, which may therefore be peculiar to that form.

At the ventral angle of the *labia pudendi* is the *clitoris* with a rounded *glans*. Its visible parts are oviform, 6 mm. long by 4 broad.

The *kidneys* of *Ovibos* are bean-shaped, without trace of division into lobules. Their dimensions in an old bull are as follows:—length 13 cm., breadth at hilus $6\frac{1}{2}$ –7 cm., thickness $4\frac{3}{4}$ – $5\frac{3}{4}$ cm. In a young cow the corresponding dimensions are 11, 6, and 5 cm. When the kidney is cut longitudinally it can be seen that there is only one elongate and ridge-like mammilla formed by the more or less complete blending of many cones into one. The cones are, however, at their bases more or less distinct. This character offers a remarkable difference from the corresponding structure in *Bos*, but agrees with that of the sheep, goats, deer, and other ruminants, even the *Camelideæ*. It is accordingly a character of importance in distinguishing *Bos* and *Ovibos*; but, on the other hand, it does not prove any closer relationship between *Ovibos* and *Ovis*, because *Bos* is in this respect an aberrant, and *Ovibos* a normal ruminant.

Concerning the *mammary organs* of *Ovibos*, it is stated by various authors with more or less certainty that the udder is provided with only two teats. This statement is, however, erroneous, as *Ovibos*, both females and males, normally have four well-developed teats. On the 11th of July, Mr. Arwidson preserved the udder of a young cow shot in Queen Augusta Valley. The udder had four teats, the anterior pair situated 8 cm. apart. The posterior pair measured 25 mm. in length, and 4 cm. apart; the distance between the two pairs being 5 cm. On the 26th of August, an old cow, with milk in the udder, was killed at Emperor Franz Joseph Fjord. She had four normal teats and one accessory. The anterior of these measure in the preserved state about $3\frac{1}{2}$ cm., and the posterior 4– $4\frac{1}{2}$ cm. The fifth accessory teat is close to the base of the right anterior one, and is not quite $1\frac{1}{2}$ cm. long in the preserved state. In a bull killed in July on Sabine Island, Mr. Arwidson found four teats and a fifth accessory one. "At the base of the scrotum," he writes, "two rudimentary teats were situated 7 cm. apart, 5 cm. in front of these was another pair, and 6 cm. in front of these on the left side still another of small size, but the corresponding one on the right side is missing. The posterior ones are larger, measuring 1.5 cm." The udder of the cow is densely covered with hair, and even the teats, although more sparsely, are beset with hairs of a lighter, nearly white coloration. The aperture in the tip of the teats is large. In their shape the teats resemble those of the cow, although smaller and hairy.

The alleged presence of only two teats has been regarded as evidence for allying *Ovibos* with the Ovine Ruminants. The opposite view is, perhaps, proved by the existence of four teats. Indeed, the evidence is more than this; because, if there had only been two, one pair might have been reduced by parallelism, since the presence of two pairs is the primary condition, as may be gathered from

the fact that four teats are found in the *Camelidæ*, in *Giraffa*, and in the *Cervidæ*. That the teats in some forms have been reduced independently is more than probable, when we take into consideration the conditions presenting themselves in the Antelopes. In the Bubaline section, for instance, *Bubalis*¹ has only two, but *Connochætes* has four teats; and a similar difference is also found in the subfamily *Antilopince*, in which all the genera have two teats except *Saiga*, which has four.

Fig. 14.



Udder of the female Musk-ox.

The ante-orbital pit or *sinus sebaceus* is well developed in *Ovibos*. On the salted head of a cow I found the glandular organ to have a lenticular shape, 23 mm. long, 18 broad, and 8 thick. It was situated in a shallow groove of the lacrymal bone, in the angle formed by the protruding orbital tube against the facial portion of the skull. It is placed rather high, as it is on a level with the upper third of the orbit. The interior of the pit itself is hairy, and round it the glands are arranged and surrounded by a capsule of connective tissue.

¹ Sclater & Thomas: The Book of Antelopes, vol. i. p. 5.

The presence of such a gland is a feature common not only to the Sheep, but to a great number of Antelopes, Deer, and other Ruminants. It is thus certainly an ancient characteristic. Its presence in the Musk-ox does not therefore prove close relationship to other forms having such a gland; and where it is missing, it may have been reduced independently in different forms.

Both in the fore and in the hind feet of the Musk-ox I have failed to find any glands. This is again another difference from *Ovis*.

It is chiefly on the study of the skeleton that the classification of the Musk-ox has been based, the soft anatomy having been almost unknown. In his paper on *Ovibos* in the Palæontographical Society's Monographs, vol. xxv., Prof. Boyd Dawkins has treated of the early opinions about this animal. We find there that the Arctic explorers and the first zoologists to whom the animal was known regarded it as a kind of ox, this being expressed by its first scientific name, *Bos moschatus*. Blainville thought he recognized in the Musk-ox intermediate characters between sheep and ox, and introduced in 1816 the name *Ovibos*, which has been adopted by most authors.

Owen believed, however, that the Musk-ox was more nearly related to the Cape Buffalo and therefore named it *Bubalus moschatus*. Rüttimeyer placed *Ovibos* near *Budorcas*, and both of these forms near the Sheep¹. Quite lately the affinity between *Budorcas* and *Ovibos* has been pleaded by Matschie². Lydekker, in his 'Wild Oxen, Sheep, and Goats of All Lands,' placed *Ovibos* as a form "*incertæ sedis*"; but it seems as if most recent authors are inclined to regard it as a true Sheep, although of a somewhat aberrant type. The question has always been, "Is it a bovine or an ovine form"? No other possibility has been discussed, except that it might perhaps be an intermediate link. Then, as there seemed to be more likeness with the Sheep than with the Oxen, the decision, as a rule, has favoured the Sheep with this strange form. The different reasons which have prevailed with zoologists to form such a judgment are chiefly founded on osteological characters; and therefore, as I hope soon to have the opportunity of treating the osteology of the Musk-ox in a separate paper, when I shall enter upon a discussion of the value of these characters, I now confine myself to consider what conclusions may be drawn from the sketch of the soft anatomy given above.

If we first ask, in what respects does *Ovibos* agree with the Ovine type, and what is the value of those characters, we arrive at the following result. The hairiness of the muzzle is a resemblance but a rather doubtful one, as *Ovibos* may independently have obtained this characteristic as an adaptation, and then as a parallelism to the same feature in the Reindeer. This seems the more probable as the broad shape of the Musk-ox's muzzle, and the absence of the mid-fissure of the lip, tend to show that its development has advanced in a different direction from that of the Sheep. On the

¹ Abh. Schweiz. pal. Ges. 1877 & 1878.

² Sitzungsab. Ges. nat. Freunde, Berlin, 1898.

other hand, as several of the Antelopes, the Llamas, and certain other Ruminants have hairy muzzles, it is possible that this is an ancient character, retained alike by *Ovibos* and *Ovis*. Whichever of these theories may be true, neither gives any reason for classifying the Musk-ox with the Sheep.

The resemblance between the Musk-ox and Sheep with regard to the relative dimensions of the right and left sacs of the paunch is shared by members of *Cervidæ*, and is therefore an ancient characteristic, merely indicating that the paunch is less developed than in *Bos*, the most specialized ruminant. The union of the pancreatic duct with the ductus choledochus has already been discussed. It indicates that one of the two primary ducts has become reduced, and the same retained in both *Ovibos* and *Ovis*, and may well be an independent parallelism. The "oviform" shape of the lobus spigelii is of no importance. The peripheral situation of the last centrifugal coil of the colon in *Ovibos* and *Ovis* is the same as in the *Cervidæ*; and is thus an ancient character, with regard to which *Bos* alone differs from the others. The same may be said about the non-lobated kidneys of the Musk-ox. The presence of ante-orbital glands is also an ancient character, common to many ruminants, although these have been reduced in *Bos*, *Cupra*, some Antelopes, &c. It is thus evident that the resemblances between *Ovibos* and *Ovis* do not indicate close relationship, especially when the differences are so many and so important. For instance, the absence of the median fissure in the upper lip indicates that the muzzle of the Musk-ox has been differentiated from the ancient type still retained by the Sheep. The reticulum of the Musk-ox is smaller than the psalterium, and the abomasus differs in the number of plicæ, &c. These are features of a separate development, as are the greater number of colic coils. The spleen differs from that of the Sheep and other Cavicornia, and may be of an ancient type. The slight development of the *septum membranaceum* in the posterior part of the nasal cavity separates *Ovibos* from the Ovine type; and the same is the case with the differences indicated by the great development of the larynx of the Musk-ox, its peculiar trachea, and the undivided left lung. The shape of the Musk-ox's penis is different from that of the Ovine group. The number of cotyledons in the placenta is unusually large, and the number of teats is the primary four; both these being important characters which distinguish the Musk-ox from the Sheep. To these may be added characters of minor importance, such as the denticulated palatal ridges¹, the flattened shape of the *lobus caudatus* of the liver, the valves in the vagina, the absence of the foot-glands, &c. Taken together, all seem to prove that the soft anatomy of the Musk-ox not only does not speak for its affinity with the Sheep, but even plainly prohibits its inclusion in the same group of the Cavicornia. Neither is it allied to the Bovine group. The anatomy of *Budorcas* is not

¹ The irregular arrangement of the *papillæ circumvallatæ* compared with the regular rows in *Bos* and *Ovibos* may be an ancient feature.

known, at least not to me, and therefore I am not able to judge concerning the alleged affinity between *Ovibos* and *Budorcas*. So much may, however, be said, that if there should exist any great affinity between these forms, *Budorcas* cannot be a Sheep. It is to be regretted that the anatomy of the Antelopes is so incompletely known. When our knowledge of them becomes greater, then only will a satisfactory classification of the Cavicornia be possible. But, to judge from its soft anatomy, the Musk-ox is entitled to form a subfamily of its own, at least *pro tempore*, as well defined as the *Caprinæ* or the *Bovince*.

3. On a Species of Earthworm from Western Tropical Africa, belonging to the Genus *Benhamia*. By FRANK E. BEDDARD F.R.S., &c.

[Received January 30, 1900.]

A few weeks ago I received, through the kindness of Mr. Martin Woodward, a bottle containing some Earthworms which had been collected in Ashanti, and which I refer to two distinct species, both of which, so far as I can see, have already been characterized. As, however, I am able to extend our knowledge of at least one of these, I think it worth while to bring the notes of my dissections before the Society.

Benhamia cæcifera (W. B. Benham).

Five years ago Dr. Benham described¹ a large Earthworm from the Gold Coast which he referred to the genus *Benhamia*, and to a new species of that genus named by him *B. cæcifera* on account of the numerous cæca with which the intestine was furnished. The larger specimen of those kindly presented to me by Mr. Woodward appears to belong to this species. Dr. Benham's example is in the collection of Earthworms in the British Museum; and—as it was the type of his new species—he was compelled to respect its integrity as much as possible. I have been under no such necessity, and am able therefore in a few points to supplement his description. In order to avoid useless repetition, I shall in the following notes upon this species abstain from commenting upon such facts as are, according to my own investigations, rightly described in Dr. Benham's memoir. I shall only deal with those matters which he was compelled to leave unnoticed, or as to which my own observations do not agree with his. The different state of maturity of our two examples enables me, moreover, to add facts which were evidently not apparent in Dr. Benham's specimen.

The worm was fully mature and 80 cm. long. Though much softened through imperfect preservation, a number of points were

¹ "On *Benhamia cæcifera*, n. sp., from the Gold Coast," Quart. Journ. Microsc. vol. xxxvii. p. 103.